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Identification of land use and land cover in Nipa-Nipa Forest Park, Southeast Sulawesi Province, Indonesia

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Identification of land use and land cover (LULC) in the Nipa-Nipa Forest Park area offers essential insights into forest degradation and deforestation within protected regions. This study aims to assess land cover changes in the Nipa-Nipa Forest Park area through the analysis of Landsat 8 OLI images from 2014 to 2024. The study utilized Maximum Likelihood Classification (MLC) in conjunction with a map overlay for the years 2014, 2019, and 2024. The results of the analysis show that in 2014 and 2019, shrubs dominated the land cover class by 48.34% and 53.07%, respectively, while in 2024 the forest land cover class dominated by 55.81%, but each class for each period showed area dynamics, where 2014-2019 period, shrubs (372.85 Ha), settlements (11.17 Ha), and agriculture (7.77 Ha) experienced area increases, while forest (-387.37 Ha) and open land (-4.43 Ha) experienced a decrease in area. while in the 2019-2024 period, there was a significant increase in forest areas (1,085.68 Ha), agricultural land (434.31 Ha), and settlements (41.06 Ha). In contrast, there were notable decreases in shrubland (-1535.23 Ha) and open ground (-25.81 Ha). The Nipa-Nipa Forest Park area has been significantly altered and is characterized by the presence of forest and shrub vegetation.
Keywords: Land use and cover, forest parks, biodiversity, ecosystem, remote sensing, climate change.

INTRODUCTION

Forest park is a protected area that function as nature conservation for the purpose of collecting biodiversity. According to the Directorate General of Ecosystem Natural Resources Conservation of the Ministry of Environment and Forestry in 2019, Indonesia has 34 Forest park, one of which is located in Southeast Sulawesi Province, specifically Nipa-Nipa Forest Park. Nipa-Nipa Forest Park area was instituted pursuant to the Decree of the Minister of Forestry Number: 103/Kpts-II/1999, dated March 1, 1999, encompassing an expanse of 7,877.5 hectares. This region is situated within the administrative boundaries of Kendari City, encompassing an expanse of 2,302 hectares and Konawe Regency, which spans 5,574 hectares. Consequently, in accordance with Government Regulation No. 38 of 2007, the stewardship of forest areas falls under the jurisdiction of the Southeast Sulawesi Provincial Government. The region is segmented into four distinct blocks: the Protection block, encompassing an area of 3,319.2 hectares; the Utilization block, spanning 3,347.5 hectares; the Plant Collection block, which covers 699.5 hectares; and additional blocks totaling 711.3 hectares (Rustam, 2013). The protected forest block functions as a water management buffer covering two administrative areas, namely Kendari City and South Konawes Regency, while in the utilization block, plant block and additional block, the area is utilized through the Community-Based Forest Management program within the Forest Conservation Farmer Group) institution.

According to Southeast Sulawesi Regional Regulation No. 6 of 2004, the management of Nipa-Nipa Forest Park seeks to guarantee the sustainability of the forest area's functions and ecosystem, the enhancement of plant and animal collections, the potential of the area's natural environmental conditions, the optimal utilization of the area for environmental services, research, education, and science, as well as the support of cultivation and the welfare of the surrounding community. This area serves as a life support system, encompassing

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carbon absorption, water resource management, and water catchment to mitigate the risks of flooding, erosion, and coastal shallowing (Kendari Bay, Banda Sea, and Lasolo Bay). It also preserves biodiversity and the distinctiveness of the natural landscape, while contributing to the Original Income of the Southeast Sulawesi Region. Currently, the Nipa-Nipa Forest Park is subjected to multiple pressures, both natural and anthropogenic (Kusmana, 2019; Gaveau *et al.*, 2021), including illegal logging and land conversion for agricultural and residential purposes (Setiawan *et al.*, 2022). Moreover, accessibility that facilitates community access to and utilization of land induces swift alterations in land cover. Indirect alterations in land cover may adversely affect biodiversity loss in the region and result in economic detriment for surrounding communities due to the disruption of the area's role as a buffer for human existence. The advancement of remote sensing technologies and Geographic Information Systems has facilitated the precise monitoring and analysis of land cover changes in response to these difficulties (Hansen *et al.*, 2021; Banskota *et al.*, 2021). Remote sensing photography provides a comprehensive representation of objects, regions, and events on the Earth's surface, accurately reflecting their form and location (Siti, 2018). Given this circumstance, remote sensing applications are essential for developing policy directions aimed at managing land cover changes in the Nipa-Nipa Forest Park to ensure sustainability

MATERIALS AND METHODS

***Location*:** This study was conducted in Nipa-Nipa Forest Park, Southeast Sulawesi Province (Figure 1) from September to November 2024. This site is situated north of Kendari Bay. Nipa-Nipa Forest Park is situated between 03°54'05" and 03°58'00" South Latitude, and 122°29'38" and 122°04'25" East Longitude. It administratively traverses two regencies/cities: Kendari City (Kendari, West Kendari, and Mandonga Districts) and Konawe Regency (Soropia and Lalonggasumeeto District).

Procedure: The stages of the study include data collection, image pre-processing, image processing, and accuracy testing.

***Data collection*:** The data utilized in this study are the findings of field groundcheek and Landsat 8 OLI satellite images obtained in September 2024 from http://earthexplorer.usgs.gov/. Table 1 shows the properties of the Landsat 8 OLI image spectrum.

***Image pre-processing*:** Image pre-processing includes geometric, radiometric, and atmospheric corrections (Kete *et al.*,2019). Geometric correction is performed to acquire coordinates that correspond to the study area (Prahasta, 2021) by utilizing metadata from Landsat 8 OLI satellite imagery. Radiometric correction improves data quality through picture contrast sharpening by adjusting the value of each pixel in the image that has been damaged due to atmospheric influences (Chavez, 1996). The atmospheric effect causes the reflection of objects on the earth's surface to have a digital numerical value that differs from their true value (Claverie *et al.*, 2018). Radiometric correction in this work uses FLAASH (Fast Line of Sight Atmospheric Analysis of Spectral Hypercube), which has been shown successful in increasing the accuracy of multispectral pictures (Richter and Schlafer, 2018).

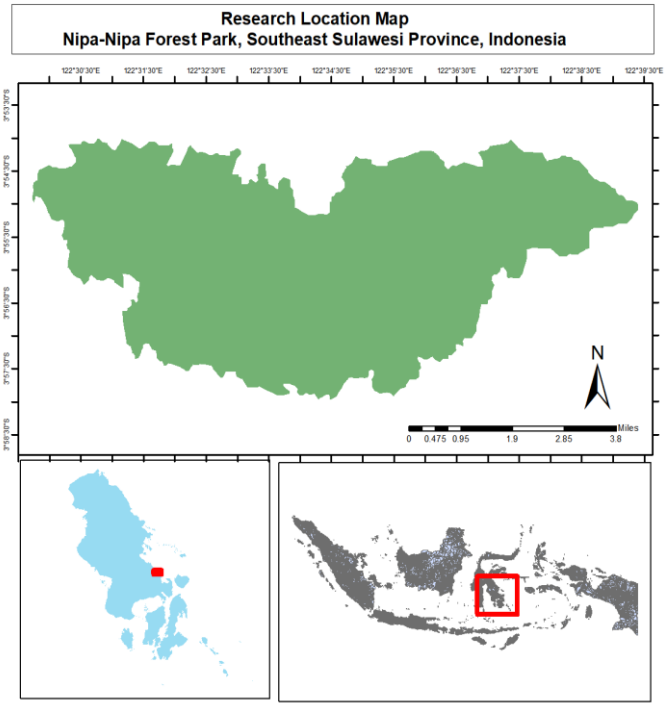

Figure 1. Research location.

Table 1. Satellite imaging characteristics from Landsat 8 OLI.

Band	Spektra	Range (nm)
1	Costal aerosol	0,43-0,45
2	Blue	0,45-0,51
3	Green	0.53-0,59
4	Red	0,64-0,67
5	NIR	0,85-1,88
6	SWIR 1	1,560-1,660
7	SWIR 2	2,100-2,300
8	Panchromatic	0,500-0,680
9	Cirrus	1,360-0,390
10	TIRS 1	10,60-11,20
11	TIRS 2	11,50-12,50

Source: www.landsat.usgs.gov

***Image processing*:** This study used the Maximum Likelihood Classification (MLC) method. MLC is a prominent parametric classification technique for land use change categorization that has been utilized globally over time

(Chowdhury, 2024). The MLC classification technique uses a covariance matrix to determine the Gaussian distribution of each spectral class based on input data (Karan and Samadder, 2018; Volke *et al.*, 2020). LULC classification is defined in the Indonesian National Standards Agency standard 7645:2010

***Accuracy test*:** The results of the land cover interpretation in 2024 were validated by field groundcheek. The verification results were then evaluated for correctness using kappa accuracy (Simamora *et al.*, 2015). The mathematical formula for calculating this accuracy is as follows.

$$\text{Kappa accuracy} = \frac{N\sum_{i=1}^{r} X_{ii} - \sum_{i=1}^{r}(X_{i+}\, X_{+1})}{N^2 - \sum_{i=1}^{r}(X_{1+}\, X_{+1})} \times 100\%$$

Description: N = number of pixels in the sample, X_1 = number of pixels in the i^{th} row, X_{+1} = The number of pixels in the i^{th} column, X_{ii} = The diagonal value of the contingency matrix's i^{th} row and column.

Table 2. Error matrix (Confusion Matrix).

Reference Data	Field Survey of Land Use				
	A	**B**	**C**	**Total**	**Producer Accuracy**
A	X11	X12	X13	X1+	X11/ X1+
B	X21	X22	X23	X2i	X22/ X2+
C	X31	X32	X33	X3+	X33/ X3+
Total	X1+	X2+	X3+	N	
User accuracy	X11/X1+	X22/X2	X33/X3	Xii	
Kappa accuracy	(X11+X22+X33+X44) / (X1++X2++X3++X4+))*100%				

RESULTS

***LULC of Nipa-Nipa forest park from 2014 to 2024*:** The identification of land cover classes in Nipa-Nipa Forest Park is based on field checks and Landsat 8 OLI images. The author classifies land cover into five categories: forest, shrubs, open land, settlements, and agriculture. RGB (654) is the composite band used in Landsat 8 OLI images. This combination was chosen because it provides a range of information dependent on the OIF value, making it easier to map land cover (Jaya, 2010).

According to the 2014 image classification results, shrubs were the land cover class with the largest area, covering 3,698.38 Ha or 48.34%, followed by forest covering 3,698.38 Ha (46.95%), open land covering 189.79 Ha (2.41%), agriculture covering 163.02 Ha (2.07%), and settlements covering 18.46 Ha (0.23%) (Table 3). Figure 2 shows the land cover map of Nipa-Nipa Forest Park in 2014.

According to the 2019 image classification results, the shrub class remains dominant and has increased in area by 4180.70 Ha (53.07%), while the agricultural and settlement classes increased in area but not significantly, at 170.79 Ha (2.17%) and 29.63 Ha (0.38%), respectively. The forest class, which covered 3,311.01 Ha (42.03%), had the greatest decline in area, while open land, which covered 185.37 Ha (2.35%), had the smallest reduction.

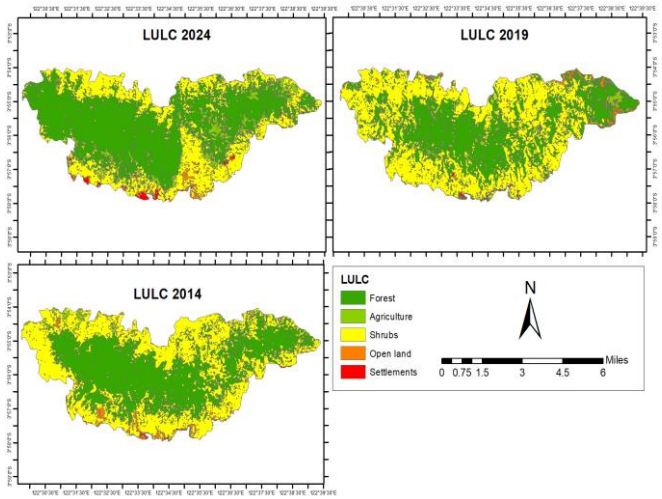

Figure 2. LULC of Nipa-Nipa forest park during multiple years.

The 2024 image classification results reveal that the forest land cover class experienced a considerable growth of 4396.68 Ha or 55.81%, the agricultural class of 605.10 Ha or 7.68%, and the settlement class of 70.69 Ha or 0.90%. Shrubs saw a substantial drop in area of 2645.47 ha or 33.58%, whereas open land saw a slight reduction of 159.55 ha or 2.03 (Figure 2 and Table 3).

***LULC changes in Nipa-Nipa forest park from 2014 to 2024*:** Analysis of LULC trends from 2014 to 2024 using Landsat 8 OLI satellite image overlay. From 2014 to 2019, there were changes in each land cover. The highest increase in area was

Table 3. LULC types in Nipa-Nipa forest park over a multi-year.

No	Classification	2014		2019		2024	
		Ha	**%**	**Ha**	**%**	**Ha**	**%**
1	Forest	3698.38	46.95	3311.01	42.03	4396.68	55.81
2	Shrub	3807.85	48.34	4180.70	53.07	2645.47	33.58
3	Open Land	189.79	2.41	185.37	2.35	159.55	2.03
4	Settlement	18.46	0.23	29.63	0.38	70.69	0.90
5	Agriculture	163.02	2.07	170.79	2.17	605.10	7.68
Total		7877.50	100.00	7877.50	100.00	7877.50	100.00

Table 4. LULC changes in Nipa-Nipa forest park from 2014 to 2024.

No.	LULC	Land Area (Ha)			Area Change (Ha)		
		2014	2019	2024	2014-2019	2019-2024	2014-2024
1	Forest	3698.38	3311.01	4396.68	-387.37	1085.68	698.31
2	Shrub	3807.85	4180.70	2645.47	372.85	-1535.23	-1162.38
3	Open Land	189.79	185.37	159.55	-4.43	-25.81	-30.24
4	Settlement	18.46	29.63	70.69	11.17	41.06	52.23
5	Agriculture	163.02	170.79	605.10	7.77	434.31	442.09

Table 5. Accuracy test results.

Classification	Forest	Shrub	Open land	Settlement	Agriculture	Total	PA	Omission error
Forest	338	0	0	1	0	339	99.71	0.29
Shrub	35	296	0	0	0	331	89.43	10.57
Open Land	0	5	100	7	1	113	88.50	11.50
Settlement	0	0	4	230	0	234	98.29	1.71
Agriculture	7	2	0	2	40	51	78.43	21.57
Total	380	303	104	240	41	1068		
UA	88.95	97.69	96.15	95.83	97.56			
Omission Error	11.05	2.31	3.85	4.17	2.44			
Overall Accuracy	94.01							
Kappa Accuracy	91.88							

shrubs at 372.85 ha, while the lowest gain was agricultural land cover at 7.77 ha. The largest land decline was forest at -387.37 ha, while the smallest was open land at -4.43 ha (Table 4).

LULC changes from 2019 to 2024 indicate that the forest category saw a significant increase of 1085.68 Ha, succeeded by the agricultural and residential categories with increases of 434.31 Ha and 41.06 Ha, respectively. Conversely, the shrub category experienced a notable area decrease of -1535.23 Ha, followed by open land with a reduction of -25.81 Ha (Table 4). A significant expansion of forested area by a forest rehabilitation program that converts shrubland and open land. Furthermore, agricultural land witnessed an expansion in area incorporating agroforestry systems featuring cashew, rambutan, and durian species.

From 2014 to 2024, the land cover type in the Nipa-Nipa Forest Park area that saw the most significant increase in area was forest, expanding by 698.31 hectares, followed by agricultural land at 442.09 hectares and settlements at 52.23 hectares. Simultaneously, the land categories that underwent a decrease in area were shrubs (-1162.38 Ha) and open land (-30.24 Ha) (Table 4).

***Accuracy test*:** An accuracy test is performed to evaluate the appropriateness and quality of image classification outcomes compared to field settings, based on producer accuracy, user accuracy, total accuracy, and kappa value. Producer accuracy is the percentage of each object in the field that is accurately classified, whereas user accuracy reflects the percentage of classification outcomes that correspond with actual field conditions. Total accuracy comprises the outcomes from both producers and users (Congalton and Green, 1999).

This study also performed a kappa accuracy test. The accuracy test results showed a total accuracy score of 94.01% and a kappa value of 91.88% (Table 5). Landis and Koch (1977) found that classification results were highly accurate (<85%). In general, land cover has been classified well, with producer and user accuracy scores greater than 88%, with the exception of the agricultural class, which has a value of 78.43%, indicating a 21.57% classification mistake. This low accuracy value is caused by agriculture being located near or linked with woodlands and bushes, which can have similar spectral properties. However, this figure is still rated as medium-high accuracy, indicating that the agricultural land classification results can be believed.

DISCUSSION

LULC changes in the Nipa-Nipa Forest Park area demonstrate significant dynamics in the use and use of space in protected areas. The analysis's findings show that the composition of the major land cover classes has changed, with a focus on shrubs and woods, as well as relative changes in open land, agriculture, and settlements. These changes reflect the complex dynamics between conservation efforts and human pressures. This is in line with previous studies conducted around the research area (Kete *et al.*, 2020; Rahmi *et al.*, 2021; Aldiansyah *et al.*, 2023).

Over the last ten years, the area has seen deforestation and land degradation as a result of illegal logging and land invasion for agricultural and settlement purposes. This shows that the region has already been disturbed, which has hindered the recovery of forest cover. Although forest cover remains

dominant, the loss of forest areas can contribute to a deterioration in ecological functions such as hydrology, wildlife habitat, and carbon sequestration. This is in line with research conducted by (Garg *et al*., 2019; Banerjee *et al*., 2020; Khachoo *et al*., 2024). Furthermore, the increase in residential land requires more attention; while it remains a small portion of the total area, the increase in settlements indicates increased pressure from the surrounding community on the protected area, which has an impact on the management and preservation of the ecosystem in the Nipa-Nipa Forest Park.

To avoid harm, maintain biodiversity, and ensure the long-term viability of ecosystem functions, the Nipa-Nipa Forest Park region must be managed sustainably. Strengthening oversight is critical in addressing issues such as deforestation, land degradation, illegal activities, and population pressure. As a result, strategic steps such as the use of remote sensing technology, supervisory officer capacity strengthening, increased personnel numbers, agency collaboration, community participation, environmental awareness development, economic incentives, stronger sanctions, and reforestation and land restoration are required. These efforts are expected to help preserve forest regions while also contributing to environmental sustainability and community welfare.

***Conclusion*:** The Nipa-Nipa Forest Park area is covered with forest, shrubs, open land, settlement, and agriculture. Changes in land use from 2014 to 2024 exhibited variance. Forests increased by 698.31 ha, whereas shrubs decreased by -1162.38 ha. The land cover classification achieved great accuracy, with total and kappa values of 94.01% and 91.88%, respectively.

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